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(54) **[Title of the Invention]** Method for Heat Treating Substrate and Heat Treating Device

(57) **[Claims]**

[Claim 1] A method for heat treating a substrate characterized by comprising: a step of performing heat treatment with a substrate to be treated supported on pins that are fixed on a heating plate so as to provide a first separation that is sufficient to prevent direct contact between said heating plate and said substrate to be treated; and a step of performing heat treatment with said substrate to be treated supported on above said heating plate by pins adapted so as to be movable, with said substrate to be treated supported, so as to provide a second separation between said heating plate and said substrate to be treated that is greater than said first separation.

[Claim 2] A device for heat treating a substrate characterized by comprising: pins fixed on a heating plate for performing heat treatment with a substrate to be treated supported so as to provide a first separation that is sufficient to prevent direct contact between said heating plate and said substrate to be treated; and pins adapted so as to be movable while treating said substrate to be treated; and by a constitution whereby, after performing heat treatment with said substrate to be treated supported on said pins that are fixed on the heating plate, heat treatment is performed with said substrate to be treated supported above said heating plate by said pins adapted so as to be movable while supporting said substrate to be treated, so as to provide a second separation between said heating plate and said substrate to be treated that is greater than said first separation.

[Detailed Description of the Invention]

Object of the Invention

Field of Industrial Application

The present invention relates to a method for heat treating a substrate and to a heat treatment device.

Prior Art

In general, there are several processes in which a substrate such as a semiconductor wafer is

processed by heating to a predetermined temperature as part of manufacturing processes for semiconductor devices and the like.

For example, fine circuit patterns in semiconductor devices are formed on substrates such as semiconductor wafers using photolithography techniques. These photolithography processes include so-called baking processes wherein, for example, a semiconductor wafer to which a photoresist has been applied, or a semiconductor wafer that has been exposed and developed following the application of the photoresist, is heated to a predetermined temperature.

Such heat treatment of semiconductor wafers is often performed by conventional methods such as those wherein [the wafer] is heat treated by placing it on a hot plate, referred to as a hot plate[1] or the like.

Furthermore, recent increases in the degree of integration of semiconductor devices has led to finer circuit patterns, resulting in a demand for ever higher precision in substrate heat treatment temperatures during heat treatment. Meanwhile, there is a trend toward increased semiconductor wafer diameters. Consequently, if the semiconductor wafer is placed directly on the hot plate as described above, the semiconductor wafer warps as a result of absorbing this heat, so that a space is formed between the hot plate and this warped wafer, [resulting in] uneven contact, as a result of which it is difficult to maintain a uniform in-plane temperature in the semiconductor wafer.

Thus, methods have also been employed wherein, for example, the semiconductor wafer is placed on a plurality of pins, provided so as to protrude from the top of the hot plate, so as to provide a gap between the hot plate and the semiconductor wafer, referred to as a proximity gap or the like, and uniformly heat the semiconductor wafer with radiant heat from the hot plate.

Furthermore, technology disclosed in JP-5918167-A establishes the treatment temperature by controlling the gap between the hot plate and the wafer, in order to establish heating temperatures with even greater precision. In heat treatments of this sort, it is sometimes required that the heat treatment temperature be incrementally varied in such a manner that, for example, after performing the heat treatment at a predetermined temperature of 200°C, further heat treatment is performed at 220°C.

It may be noted that, in general, factors such as heat capacity mean that hot plates of the sort described above are not capable of substantial temperature variation, because a very long period of time is required to stabilize the temperature when the temperature is changed. It is thus conventional to provide a plurality of hot plates at different temperatures and to successively transport the semiconductor wafer between the hot plates so as to progressively vary the heat treatment temperature.

Problems to Be Solved by the Invention

As described above, when the heat treatment temperature is incrementally changed, it is conventional for heat treatment to be performed by successively transporting the substrate between a plurality of hot plates at different temperatures.

However, in such conventional methods for heat treating wafers, as a plurality of hot plates are necessary, larger equipment is necessary for the heat treatment. Furthermore, the substrate cools during transport, resulting in improper heat treatment temperatures. There were [also] such problems as decreases in throughput due to increased transport steps.

The present invention is a response to the existing situation, and is directed at providing a method for heat treating a substrate and a heat treatment device that allow for reductions in size.

<u>Constitution of the Invention</u>

Means for Solving the Problems

In other words, the present invention is characterized by comprising: a step of performing heat treatment with a substrate to be treated supported on pins that are fixed on a heating plate so as to provide a first separation that is sufficient to prevent direct contact between said heating plate and said substrate to be treated; and a step of performing heat treatment with said substrate to be treated supported above said heating plate by pins adapted so as to be movable, with said substrate to be treated supported, so as to provide a second separation between said heating plate and said substrate to be treated that is greater than said first separation.

Furthermore, the invention in Claim 2 is characterized by comprising: pins fixed on a heating plate for performing heat treatment with a substrate to be treated supported so as to provide a first separation that is sufficient to prevent direct contact between said heating plate and said substrate to be treated; and pins adapted so as to be movable while treating said substrate to be treated; and by having a constitution whereby, after performing heat treatment with said substrate to be treated supported on said pins that are fixed on the heating plate, heat treatment is performed with said substrate to be treated supported above said heating plate by said pins adapted so as to be movable while supporting said substrate to be treated, so as to provide a second separation between said heating plate and said substrate to be treated that is greater than said first separation.

Action

In the method for heat treating a substrate and the heat treatment device of the present invention, the substrate to be treated is placed, for example, on a plurality of pins provided so as to protrude from the top of the hot plate, and the substrate to be treated is established at the treatment temperature by raising and lowering the pins and the hot plate with respect to each other so as to vary the gap between the hot plate and the substrate to be treated.

Accordingly, there is no need for a plurality of hot plates, nor is it necessary to successively transport the substrate to be treated between hot plates. Furthermore, it is possible to heat the substrate to be treated for the desired period of time and at the desired temperature without varying the temperature of the hot plates. Consequently, it is possible to reduce the size of the device for heat treatment.

Embodiments

Hereinafter, one embodiment of the method of the present invention as applied to heating a wafer is described with reference to the drawings.

As shown in FIG. 1 and FIG. 2, a hot plate 1 of a heat treatment device is formed substantially as a disc having a diameter greater than that of the substrate to be treated, which is for example a semiconductor wafer, at the interior of which a heating mechanism, such as a resistance heater or a film-type heating element, not shown in the drawings, is provided.

Furthermore, a plurality of through holes 2, such as for example three through holes 2, are provided in this hot plate 1, and pins 4 are provided in these through holes 2 so as to pass through the hot plate 1 for the purpose of supporting a substrate, such as for example a semiconductor wafer 3, on top of the hot plate 1. These pins 4 are made of a material having

[1] *A phonetic transcription of the English term "hot plate" is used in the original Japanese text.*

a low thermal conductivity, such as a ceramic, so that they do not readily transmit heat from the semiconductor wafer 3 and the hot plate 1. Next, these pins 4 are supported by a roller base 6, which is provided below the hot plate 1, by way of support shafts 5, so that the height at which these pins 4 protrude from the top of the hot plate 1 is adjustable by way of a screw or the like.

The lower extremities of a plurality of prop shafts 7, such as for example three prop shafts 7, are fixed on the roller base 6. Meanwhile a pin base 9 is fixed on a base 8 so as to be positioned above the roller base 6. Next, the upper extremities of the prop shafts 7 are supported by the pin base 9, by way of coil springs 10 and bearings 11, so as to allow vertical movement.

Furthermore, a pulley 13, to which a cam plate 12 is fixed, is provided on the pin base 9. The constitution is such that this pulley 13 is connected to a pulley 16 provided on a step motor 15, by way of a timing belt 14, and can be driven by the step motor 15.

Note that the constitution is such that, as shown in FIG. 2, a tension roller 17 is provided so as to push against the timing belt 14, so as to absorb elongation or contraction of the timing belt 14 caused by thermal expansion or the like, so that the step motor 15 reliably drives the pulley 13.

Meanwhile, on the roller base 6 is provided a roller 18, paired with the cam plate 12, which is provided on the pin base 9. The constitution is such that this roller 18 is pushed against by the cam plate 12 as a result of the elastic force of the coil springs 10. Next, the constitution is such that, when the pulley 16 and the cam plate 12 are rotated by the step motor 15, the roller 18 is moved up and down by the travel of the inclined lower face of the cam plate 12, whereby the roller base 6 and three pins 4, which are supported by the roller base 6, are moved up and down.

Note that a minimum of three pins support the wafer, and that the height at which these protrude from the top of the hot plate 1 is chosen according to the desired range of variation, the constitution being such that it is possible to freely establish the height within a range of, for example 0.00 to 2.00 mm. Furthermore, the constitution is such that the hot plate 1 can be displaced vertically with respect to the base 8 and the pin base 9, by means of a drive mechanism not shown in the drawing, such as an air cylinder; the constitution is also such that, when loading and when removing the semiconductor wafer 3, the hot plate 1 is vertically displaced so that the pins 4 protrude approximately several centimeters from the top of the hot plate 1, so as to provide a gap into which it is possible to introduce a transport arm or the like, for the purpose of transporting the semiconductor wafer 3.

Furthermore, a cooling mechanism, such as a coolant conduit 19, is formed in the pin base 9. Thus, by circulating a coolant such as cold water in this coolant conduit 19, the pin base 9 and mechanisms such as those for raising and lowering the pins 4 as described above are cooled so as to reduce the influence of the heat from the hot plate 1 and prevent a pin-height error, resulting, for example, from thermal expansion.

Furthermore, in addition to the pins 4, the hot plate 1 described above is provided with a plurality of proximity pins 20, such as for example [*sic*] proximity pins 20, having a fixed height. Parts such as the so-constituted hot plate 1 are disposed within a case 21 and a heat insulating material 22 or the like is provided on top of the hot plate 1.

In the present embodiment, the heat treatment device having the constitution described above is used to heat treat a substrate such as the semiconductor wafer 3 in, for example, the following manner.

That is to say, a heating plate 2 [*sic*] is set to a predetermined temperature beforehand, and with the pins 4 protruding from the heating plate 2, the semiconductor wafer 3 is placed on these pins 4, for example by a transport device.

Next, the pins 4 are lowered so that the semiconductor wafer 3 is placed on the proximity pins 20. Note that the proximity pins 20 are set beforehand so that the gap between the hot plate 1 and the semiconductor wafer 5 [*sic*] (proximity gap) is equal to a predetermined value such as, for example, approximately 0.01 to 0.10 mm.

After heating for a predetermined period of time such as 5 to 10 seconds in this state, the step motor 15 is driven to raise the pins 4 so that the semiconductor wafer 3 is received by the pins 4 from the proximity pins 20 and the proximity gap is set to a predetermined value, and heat treatment is performed for a predetermined period of time. Then, if the treatment temperature is to be further varied, the pins 4 are raised or lowered by the step motor 15 so as to adjust the proximity gap, whereby the treatment temperature for the semiconductor wafer 2 [*sic*] can be set to the desired temperature without changing the temperature of the hot plate 1.

Note that the relationships between the temperature of the hot plate 1 and the temperatures of the proximity gap and the semiconductor wafer 3 are determined beforehand by experimentation or the like, and it is necessary to establish the value for the temperature of the hot plate 1 and the proximity gap in accordance therewith.

As described above, by virtue of the method for heat treating a substrate according to the present invention, it is possible to treat the semiconductor wafer 3 while changing the temperature thereof, without changing the temperature of the hot plate 1. Accordingly, it is not necessary to transport the semiconductor wafer 3 in order to change the treatment temperature, nor are a plurality of hot plates 1 required, whereby it is possible to reduce the size of the device and increase throughput, as well as to achieve stable heat treatment at the correct temperatures.

Furthermore, it is a matter of course that the mechanisms for adjusting the height of the pins 4 and the like may be constituted in any manner.

Furthermore, the embodiment above describes an example wherein the vertical movement of the wafer is adjusted within a previously established range, but if a sensor for measuring the temperature of the wafer is provided and an adjustment signal is output from a microcomputer so as to adjust the vertical position of the wafer so that the output of the sensor reaches a previously established temperature, even more precise temperature adjustment becomes possible. Such a plurality of temperature settings can for example, be applied to a step of spin-coating a resist, a step of baking following resist application, and a step of spin-developing following exposure.

Effects of the Invention

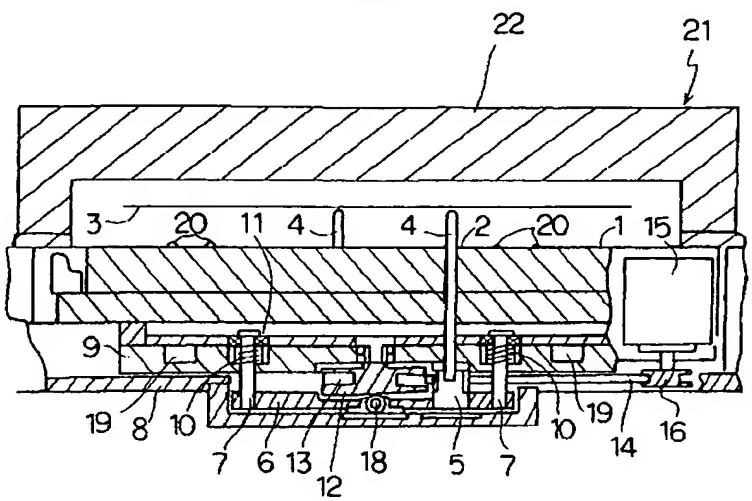
As described above, by virtue of the method for heat treating a substrate and the heat treatment device of the present invention, it is possible to reduce the size of the device for heat treatment.

[Brief Description of the Drawings]

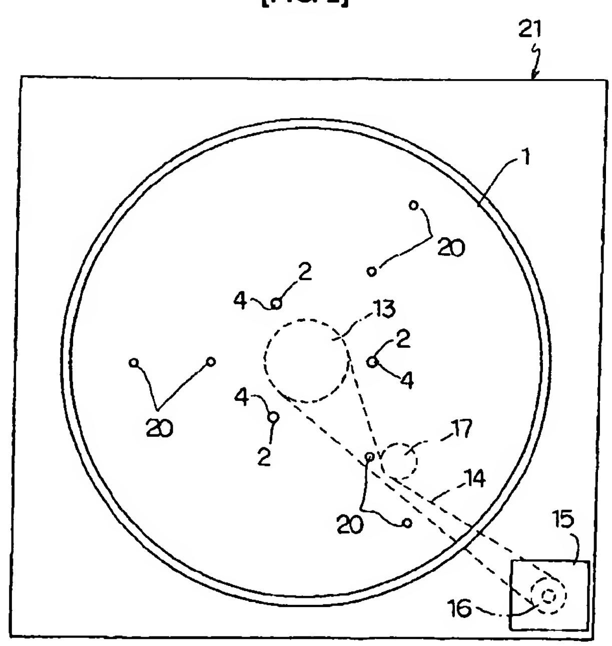
FIG. 1 and FIG. 2 are structural diagrams of a heat treatment device serving to describe one embodiment of the method for heat treating a substrate of the present invention.

1	hot plate
2	through hole
3	semiconductor wafer
4	pin
5	support shaft
6	roller base
7	prop shaft
8	base
9	pin base
10	coil spring
11	bearing
12	cam plate
13, 16	pulleys
14	timing belt
15	step motor
17	tension roller
18	roller
19	coolant conduit
20	proximity pin
21	case
22	thermal insulator

[FIG. 1]



[FIG. 2]



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(56) **Reference Documents:**	JP-63-124424-A	(58) **Fields Searched** (Int. Cl.^{5}, DB Name)	
	JP-63-079636-U	H01L	21/027
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CERTIFICATION

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By:

November 11, 2004

Martin Cross is the president of Patent Translations Inc. and has worked for eighteen years as a Japanese to English translator and translation editor specialized in patent documents.